Communication Network for Management of Operations and Assets of Indian Railways

Synopsis
Submitted to the Symbiosis International University Pune
For the Degree of Doctor of Philosophy (Ph.D.)
in
Computer Science & Engineering

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Title of Thesis: *"Communication Network for Management of Operations and Assets of Indian Railways*"

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1. Abstract:

A railway network consists of two layers – the physical layer and the communication layer. The physical layer consists of static information such as geographical information of rail tracks, stations, routes, trains, locomotives, divisions, zones, control sections, permanent / temporary engineering restrictions, Level Crossing, Signals, RUB, ROB, Bridges, Tunnels etc. The dynamic information consists of locations of running trains, locations of locomotives, locations of rakes, status of signals etc. In order to monitor and control the railway network, the communication layer is a critical infrastructure. The communication layer is used by a traffic controller at the divisional level to control moving trains; both passenger and freight. It is also used by many other users such as station masters, passengers, merchants, etc to plan and execute various train related activities. The communication network for a railway system now consists of voice, data as well as video information.

The present work describes the design and development of a Virtual Private Network (VPN) like wireless communication network for a railway system; specifically the Indian Railways. The objective of the work is to develop such a communication system – hardware as well as software – for online tracking of trains (health of the train along with the locomotive). The design consists of both static as well as dynamic information. The dynamic information is superimposed over the static information. The dynamic information will be useful for traffic controllers to make decisions about trains running on tracks. Operational constraints have been taken into account for monitoring the movements of trains. Off-line reports of daily dynamic information can be used for improving the time table for optimal train schedules. The mathematical model of the network in terms of graphs, pipelines and maps has been developed. The information about congestions, bottlenecks, platform availability etc has also been considered.

The development of the integrated network for Kanpur-Lucknow as well as Kanpur-Allahabad sections is described in the present work. The proposed system is capable of handling bi-directional communication of data, voice and video between a train and a server; where the server is presently located at IIT Kanpur. The design of the system is such that it can be scaled up for a zone or for the entire national network. Various tests have been carried out for validating and verifying the integrity of the data communication. Depending on the bandwidth resource, it is possible to provide voice and video information.

2. Introduction:

Indian Railway Network is a huge network of tracks, stations, trains and locomotives. By 2008, most of the stations will have OFC (Optical Fiber Cable) connectivity. Before going further in details of train operations management; we present some railway

descriptions and notations. Indian Railways has seventeen zones (including Konkan Railway). These zones are further divided in to smaller parts called divisions. Currently sixty nine such divisions exist. Train-running operations are the main responsibility of divisions. For train-running operations, one division has further smaller sections. These sections are called "Control Sections". Around 30 to 45 stations come under one control section. Chief Traffic Controller (CTC) is responsible for train operations under one division. Section Controller is responsible for train running operation under one control section. Several Section Controllers come under one CTC. Train running is a fairly complex operation in Indian Railway. Section Controller has very limited information about the scene beyond his control section. So section controller runs the train as a short sighted person. Most of the time the Section Controller is unaware of the situations in the neighboring sections; and hence due to lack of complete inputs section controller may not be able to run the trains in optimal manner. One major reason of this lack of information is insufficient communication. Over and above this short sight-ness, some other very important constraints are related to locomotive availability, track availability, platform, engineering restrictions (temporary and permanent engineering restrictions). Here, a major issue is to know about foreign intervention over a control section i.e. what would be the impact of trains coming from other control section to this control section or train moving out from this control section to other control section.

The whole Indian Railway network can be viewed as a connected graph **G <V, E>** along with pipeline property. This problem can be solved using visualization of existing railway network as a combination of graph, pipeline and real time effects. A proposed solution to overcome this problem is multidimensional simulations. Simulation can be divided in to three major categories (i) simulation of railway network as graph (ii) simulation of railway network as a pipeline (iii) dynamic simulation of railway network using real time tracking data for optimal operations management.

3. Problem Statement

Due to inadequate information with train controller, one ends up with doing orbit clerical and monotonous job for Indian Railways. Due to the lack of appropriate communication network, he is not able to provide even this incomplete information to all set of people. So today IR is not able to provide the current train positional status to the waiting passengers. This results in a multi level problem of following things.

- Controller does not have necessary and accurate Information to perform the Train Running Operation in an optimized way.
- Design and Development of an Integrated Wireless Communication Network for Railway Operations is mandatory to assist controller.
- To stop the projection finding exercise (done by controller for every train in his/her section) as the Dynamic Projection is always available to him due dynamic train tracking information.
- The train location information in its most current form is available to every user connected to our proposed system. Hence, controller need not spend time on answering the positional queries regarding the latest train position; but can devote his time for better train running decisions.
- Several bottlenecks/congestions are hampering the "Train Running Operation" due to various running status of the trains. The proposed system

provides ways to detect such bottlenecks/congestions and propose practical and feasible solutions.

4. Literature Review

A brief review of the work: (National and International):

Most of the work in "***train scheduling***" is found theoretical in nature mostly with simplifying assumptions making the theoretic models nice, but fail to work in real world. Any railway track has direct or indirect impact of neighboring track. If neighboring traffic is suffering from congestion then there is a possibility of indirect or direct affect on the selected track [1], [11], [12], [13], [14]. Most of the models fail due to such ignorance. Most of the models are biased with developers' perspective and their field approach. A mathematician tries to fit this multi dimension problem in a mathematical framework. Same thing is true for algorithmic, civil engineering persons too. Any such complex problem can not be solved by such biased versions of solutions [2], [12], [14].

This problem is multi dimension in nature. The scheduling problem is a combination of graph theory, pipeline, queuing theory and real time system approach. (Here real time does not mean speed or fast) [3].

5. Research Objective:

Main objective of this thesis is to provide a real solution for train scheduling. To achieve it following objectives are to be tackled.

To do simulation using graph properties, queuing theory, stochastic variations, pipeline over real tracked data over various simple and complex tracks [4]. It has following objectives.

- Pinpoint causes which affect train-running.
- If railway wants to put a new train over a track, whether it is feasible to adjust the new train without extending any infrastructure like platforms, tracks, locomotives, coaches, man power etc.
- Tell definitively about the cause of congestion or bottlenecks. A logical solution for any congestion or bottle neck.

The work can be mainly divided in following parts:

- Study of the existing system. Gather various inputs regarding operation hindrance regarding scheduling.
- Study about the existing direct, indirect constraints. Some of these constrains would be of permanent in nature and some will be temporary in nature. Some major constraints are number of tracks, number of platforms at a station. Distance between two consecutive stations, platform length, platform facilities, etc. Some temporary constrains are flood, obstacle on the track, track maintenance, accident etc.
- Prepare a centralized database system, which can be used as baseline of the real scheduling. This work requires real time train tracking data to establish better scheduling methods.
- Try to suggest the better way of scheduling after analyzing the available static as well as dynamic data.

Optimal train running operations due to availability of required inputs through central information server and use of GSM wireless network for train/loco location data logging. This solution will also pinpoint physical bottleneck due to track and platform unavailability (busy track, busy station situation) [7], [8]. So new tracks, platforms can be proposed. It will also help in reducing track pipeline time by proposing Block Huts (BH) and Intermediate Block Section (IBS) between two consecutive distant stations. It will help in running new trains with zero or minimum timetable clashing.

A centralized database for railway has been created and it is operational. Dynamic train tracking data is also available for further optimizations which will be covered during this thesis.

6. Proposed Methodology

To convert short sight into bird's eye view (***Please refer Presentation Slides***) is the proposed methodology to solve such problem. Methodology is to establish a centralized node as information server. Information server is using a central database at backend. This database will contain information about all stations, routes, trains, rakes, locos, various divisional, zonal jurisdiction information, control section information, permanent /temporary engineering restrictions. The above mentioned data is more or less static in nature. Along with this data, trains' positional data will be used to enhance optimal train running operations. This data can be accessed by any railway person using local LAN or using internet. Now due to availability of required data, section controller will be able to run trains in an efficient manner. Controller will have information about locomotives, trains, restrictions etc. which may affect his decisions in train running operations.

Major inputs: (Infrastructure of research work):

- Centralized database of Indian Railway along with dynamic train location data is the major input for it. This infrastructure is already available with us.

- SIMRAN Project is a sponsored project in IIT Kanpur. It is a joint venture of Ministry of Railway & MHRD. Under SIMRAN project a Central Information server has been established. It is operational. It contains information related to all stations, routes, zones, divisions, control sections, locos, rakes and crossing etc. It helps to exercise bird's view over IR network. It also keeps data logged by trains for their locations. This data will be used for the dynamic simulation.

First three stages have been completed till now. Please see **Annexure-1 & Annexure-2**. Only the fourth stage is to be done. This will take around **nine months**.

Schedule of activity:

Serial no.	***Phase***	***Activity***
1	Phase1(one month)	Study of the existing scheduling system.
2	Phase 2 (one month)	Study of existing direct and indirect constraints
3	Phase 3 (done)	Preparation of a centralized database system
4	Phase 4 (six months)	Simulations
5	Phase 5 (two months)	deployment/ testing of result

Chapter scheme:
Whole thesis shall be divided into eight chapters. Description of each chapter is as follows:

Chapter 1
Introduction
In this chapter description of "The world of Network", Unique Features of Railroad Networks, Issues of Scheduling in Railroad Networks, Literature Reviews, Outline of Proposed Research Work, Scope and Limitation, Organization of Present Document topics shall be covered.

Chapter 2
Description of Railway Network
In this chapter description of bird's eye view approach will be described. An elaborated description of a Divisional Network and Control Section Network will be covered in this chapter.

Chapter 3
Operation of Railway Network
It is a crucial chapter in the whole thesis. Mainly description of railway operations (scheduling related operations) shall be covered here. A comparative study between existing system and the proposed new approach shall be described. Effect of constraints and limitations over train-running operations shall be discussed.

Chapter 4
Simulation
In this chapter description of static verses dynamic simulation shall be covered. Simulation with real time data will be used here. In this chapter various simple and complex real tracks shall be simulated. In this simulation pipeline, queuing theory and graph will be used with real tracking data.

Chapter 5
Optimal Schedule by Simulation
In this chapter result of various simulations will be compiled here. It will describe the various suggestive procedures and setups for optimized scheduling.

Chapter 6
Case Study
Cases covered during simulation will be compared here along with various other studied results obtained by others.

Chapter 7
Simulation of Unexpected Events
As we know nobody cares about disasters. In normal situation most of the things work fine. But if something goes wrong then whether new design is capable of

minimizing that effect of the failure? In this chapter fail recovery will be discussed in detail.

Chapter 8
Conclusions
After getting simulation results, it will be shown that how this result is better than the existing one.

7. Issued to be addressed :

- **How to provide real time data information layer to controller? Controller is the key person who can improve the train running a lot.**
- **Issues/problems detection due to which "Optimized Train Running" could not be achieved till now.**
- **Find out bottleneck/congestion/disorder in train running and proposed solution/s for it**
- **How to reduce impact of unanticipated problems during train operations.**

Currently railway is facing lots of problems regarding proper scheduling of its trains. Most of the times trains are late due one constrains or the other. Due to "Bird's eye view" approach such problems can be minimized in a big way. This system will be able to suggest various bottle necks in the existing system. Some such bottle necks are insufficient tracks to operate, large distance between two stations can be a bottleneck with respect to pipeline methodology, number of platform at particular nodal (junction) station. It will provide the solution to railway about traffic congested stations. Due to such stations traffic gets delayed every where. This traffic congestion is due to improper queuing of trains over platforms.

8. Conclusion:

- **How to optimize Train Running**
- **List out bottleneck/congestion/disorder along with their possible solutions which will help in optimizing train running operation**
- **How to handle and reduce impact of unanticipated problems during train regular operations.**

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